Question Sheet: Collisions

1. Show that the time between two subsequent *strong* collisions between stars can be written as

$$t_{\rm strong} \sim 4 \cdot 10^{12}\,{\rm yr} \left(\frac{v}{10\ {\rm kms}^{-1}}\right)^3 \left(\frac{m}{M_\odot}\right)^{-2} \left(\frac{n}{1\ {\rm pc}^{-3}}\right)^{-1}, \qquad (1)$$

where m is the mass of the stars, n their number density and v their relative speed.

2. The elastic scattering between photons and charged particles is called Thomson scattering. For electrons the cross section for Thomson scattering is $\sigma_T = 6.65 \cdot 10^{-25}$ cm^2. Calculate the mean free path of photons in the core of the Sun, given that the density in the centre of the Sun is $\rho = 150$ g cm^{-3}. Assume that the core of the Sun is fully ionised and consists of 25 % Helium and 75 % Hydrogen (by mass).

3. The gravitational acceleration at the Moon's surface is 167 cm/s^2, and the radius of the Moon is 1738 km. The mean temperature of the Moon is 300 K. (a) What molecular weight must a gas have so that a molecule with $\bar{v}^2$ of a Maxwellian distribution cannot escape from the Moon? (b) Why has the moon no apparent atmosphere? Relate your answer to the result obtained in part (a).

4. Interstellar atomic hydrogen is often found in neutral, HI clouds, whose temperature is 100 K. What is the rms velocity ($(\bar{v^2})^{1/2}$) of the hydrogen atoms? If the number density is $n = 1$ cm^{-3}, what is the pressure in interstellar space? The clouds also contain dust grains that might characteristically have diameters 5×10^{-5} cm and unit density. Treating the dust as though it were an ideal gas, what would be the random velocity of dust grains?

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